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STRUCTURE OF THE EARTH'S IONIZED GAS SHELL ACCORDING TO DATA OF DIRECT MEASUREMENTS OF LOCAL CHARGED PARTICLE CONCENTRATIONS CONDUCTED IN THE USSR. *)

(Stroyeniye ionizovannoy gazovoy obolochki Zemli po dannym pryamykh izmereniy lokal'nykh kontsentratsiy zaryazhennykh chastits provedennykh v SSSR)

Iskusstvennyye Sputniki Zemli (ISZ) (AES), vyp.12, pp.105—118, Izd-vo A.N.SSSR, Moskva 1962.

by K. I. Grigauz

Measurements of local concentrations of electrons and ions in the outer ionosphere (over the F-region of ionization maximum) were carried out during the past three years in the Soviet Union at vertical launchings of geophysical rockets of the USSR Academy of Sciences, aboard the third Earth's artificial satellite and by means of the first three cosmic rockets.

Speaking of measurements of "local" concentrations, we have in mind measurements consisting of a series of determinations of charged particle concentration, each of which is related to sufficiently accurately known height, does not require any assorted or assumed law of variation with altitude or horizontally, does not utilize ionospheric station meausrements, and is not the result of statistical processing of a series of any nonsimultaneous measurements. In other words, every determination of concentration is entirely localized in space and time.

The agreement of the results of the indicated experiments allows the construction of an exemplary pattern of charged particle distribution in height in the ionized gas enevelope of the Earth, the determination of its boundary, and the reaching of some conclusions on the degree of its changeability at various heights.

1. RESULTS OF MEASUREMENTS CONDUCTED WITH THE HELP OF RADIOWAVES EMITTED FROM GEOPHYSICAL ROCKETS.

Three coherent radiowave transmitters, with frequencies of 24, 48 and 144 mc/s have been installed aboard every geophysical rocket of the USSR Academy of Sciences, launched nearly vertically to 450 – 470 km altitudes. At reception of these radiowave at several points of the Earth's surface (including points near the vertical projection of the summit of rocket's trajectory) determinations of free electron concentrations at various heights are carried out by means of two methods. One of them is based upon the de ermination of radiowave dispersion (in pairs at 144 – 48 mc/s and 144 – 24 mc/s frequencies), and the other – on observations of the Faraday effect.

For the determination of distribution in height of free electrons' concentrations by observations of radiowaves' polarization plane rotation, it is sufficent to conduct these on one-frequency radiowaves, since the rockets utilized are fully stabilized over the free flight portion (i.e. three mutually perpendicular axes, rigidly connected with the rocket do not change their orientation relative to the system of coordiantes linked with the Earth during flight time). That is why the difficulties connected with the separation of Faraday effect from the effect of rotation of the radiating antenna, are absent, and the measurement of the turn of radiowaves' polarization plane by any of the emitting frequencies at passing by the rocket of a certain altitude interval allows to determine the mean electron concentration over that interval. A detailed description of the apparatus applied for such experiments has been published in reference [1].

The distribution in height of electron concentration, determined by phase measurement of radiowave dispersion during the launching of the rocket on 21 February 1958 to 470 km, was published in [2] and reported to the Vth General Assembly of the IGY in Moscow in August 1958. However, comparison of the results obtained on 21 February 1958 with those obtained during the launchings of two such rockets on 27 August and 31 October 1958, is of interest. The three rockets were launched above the very same geophysical point (at mid-latitudes of the European SSSR), and measurements of electron concentration were conducted by the same method, using identical devices. During each launching radiosoundings of the ionosphere were conducted from the ground with the aid of a ionospheric station near the launching pad. In all cases electron concentration maxima measured at rocket launching corresponded well to the critical frequencies of the F-layer.

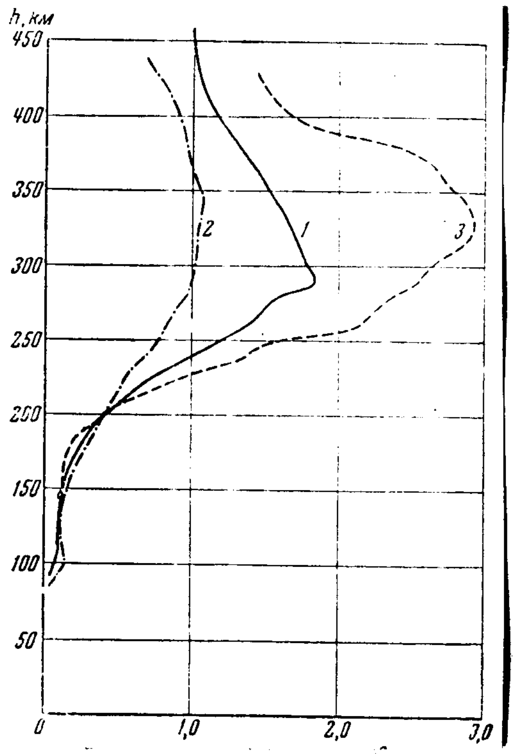


Fig. 1. Curves of electron density dependence on altitude, obtained by the dispersion method.
1 — 21 Feb.1958., 11 40 hours.
2 — 27 Aug. 1958, 08 06 hours;
3 — 31 Oct.1958, 15 54 hours.

Three distributions in height of electron concentration, obtained during the indicated launchings are plotted in Fig.1., the time shown being local time.

The turns of the polarization plane of radiowaves were measured in all cases simultaneously with measurements of their dispersion. To compare the results obtained by phase measurements of radiowave dispersion and by measurements of the Faraday effect, dependences of electron concentrations on altitude, obtained on 27 August 1958 through measurements of rotation of radiowaves' polarization plane with the frequency $f = 48$ mc/s, and through phase measurements (dotted line) are plotted in Fig. 2 . The lengths of the vertical cuts correspond to altitude intervals, for the crossing of which the polarization plane of radiowaves is deflected by the angle $\theta = \pi$.

Fig. 1 clearly shows that the vertical gradients of the electron concentration in the outer ionosphere region, lying immediately above the ionization maximum of the F-layer, vary in the strongest fashion as a function of the time of the day and year.

To characterize the ionosphere changeability in that region, we compiled in Table 1 the quantities $n_{e,\max}$, $\frac{|\Delta n_e|}{n_{e,\max}}$ (here $\Delta n_e = n_{e,\max} - n_e(h_{\max} + 100)$) where h_{mx} is the altitude in km of the electron concentration maximum and $\overline{|\mathrm{grad}\, n_e|} = \frac{|\Delta n_e|}{100}$. i. e. the quantity expressed in $cm^{-3}km^{-1}$ of the mean gradient at 100 km extent abobe the maximum of n_e.

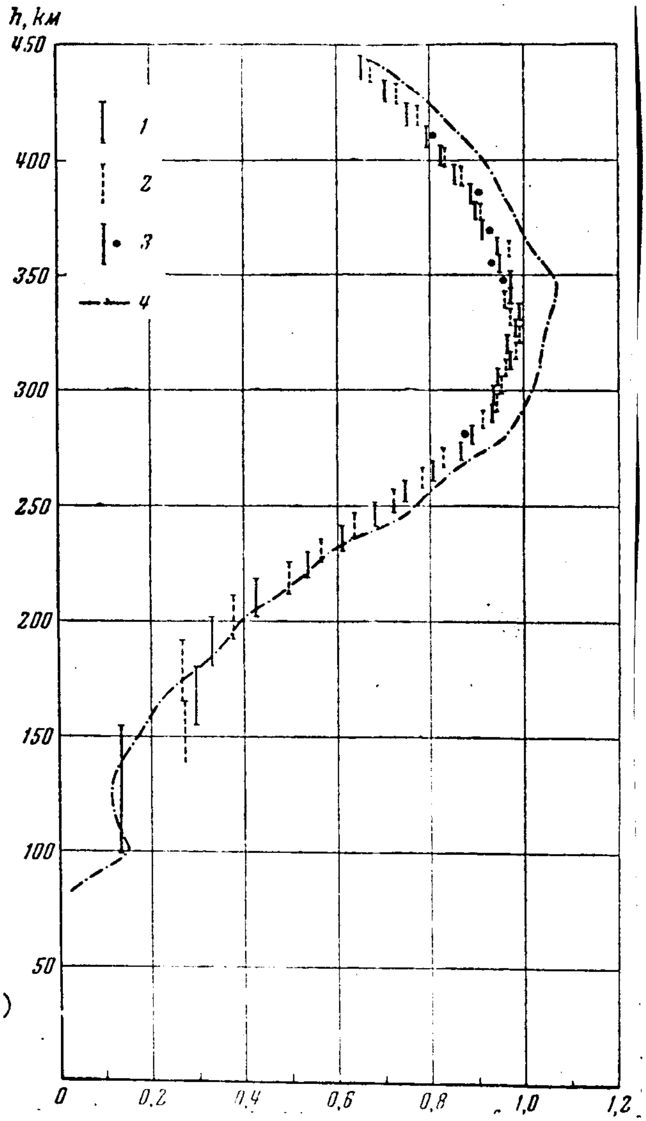


FIG 2.

Dependence of n_e on altitude, found on measurement of Faraday effect
1 - by coinciding data of 2 points. -
2 - by data from the 3rd point.
3 - coinciding data at 3 points
4 - curve plotted in Fig. 1.

There is no possibility, within the bounds of the present report, to dwell upon questions connected with the errors of our measurements based upon observations of radiowaves emitted from altitude rockets. These questions are examined in [1] and [3]. Let us only point out, that the proximity of rocket trajectory to the vertical is the most important circumstance in connection with which no assumptions have to be made concerning the magnitudes of horizontal gradients of n_e , or account for the refraction, when processing the results of measurements.

TABLE 1

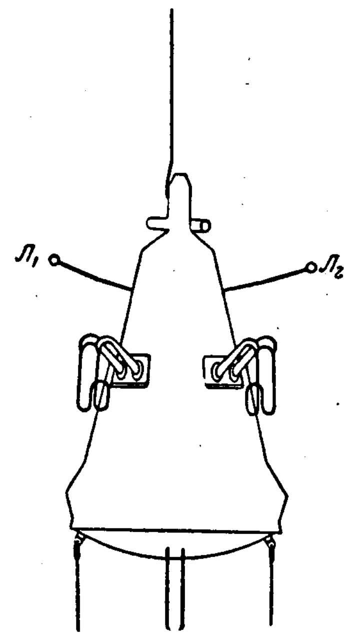
Date	Time (Moscow)	[illegible]		
21 February	11 40	1.83	0.126	2.3
27 August	08 06	1.08	0.134	1.45
31 August	15 54	2.92	0.161	4.7

2. RESULTS OF MEASUREMENTS OF THE CONCENTRATION OF POSITIVE IONS n_i BY THE METHOD OF SPHERICAL IONIC TRAPS ABOARD THE THIRD EARTH'S ARTIFICIAL SATELLITE

Experiments on positive ion concentration along the orbit ot the third AES were conducted between 15 may and 3 June 1958. All the data used below and related to these experiments were obtained in daytime (from 05 00 to 17 00 hrs Moscow time) from the ionosphere region up to 1000 km lying above the portion of the ground limited by the coordinates from 30 to 175° and from 25 to 65°

The description of the experiment has been published in 1957 [4], and more than once reproduced [5, 6]. That is why we shall only remind that the measurements of positive ion concentrations were made by way of taking down ionic volt-ampere characteristics of spherical two-electrode ionic traps, fastened to the surface of the satellite by means of long arms (Fig. 3). By ionic volt-ampere characteristic we mean the dependence of the current in the chain of the trap's collector on the voltage fed to the latticed envelope of the trap relative to satellite's frame.

In the whole complex of telemetric information related to this experiment, and obtained during the flight of the third satellite, there were more than 10 000 ionic volt-ampere characteristics. One of them was introduced at the Moscow Assembly of the IGY in 1958 (after advance preparation). It was related to the 795 km altitude level and it attested about the existence at that height of an electron concentration $n_i \approx 1.8 \cdot 10^5 \ cm^{-3}$.



As to the total processing of all obtained primary information, it resulted wery cumbersome, and it is ending just now. We have no possibility of discussing in the present report all questions connected with the method of determination of positive ion concentration in an undisturbed ionosphere by the volt-ampere characteristic (n_{i_0}), and more particularly the question of accounting the effect of ion thermal velocities on the results of processing. These questions are examined in [6]. Let us only note that the basic method of n_i determination consists in the measurement of the steepness of the ionic volt-ampere characteristic's linear portion in the region of positive ion deceleration and in the utilization of the correlation

$$n_{i0} = \frac{dI_к}{d\varphi} \frac{m_i V_{сп}}{2\alpha S e^2},$$

where $\frac{dI_k}{d\varphi}$ is the steepness of the indicated portion of the characteristic; V_{cn} is the speed of the satellite; α is the transparency of the latticed envelope; S is the surface of trap's cross section; e is the charge of the electron ; m_i is the mass of the ion.

Let us note, that according to data of the ion mass spectrometer installed aboard the third AES, the atomic oxygen ions constitute not less than 90 percent of the total number of ions from 250 to 1000 km heights [7].

In a series of cases comparison was made of quantities n_{i_o} determined by the ion trap data from the third AES at its passing the region of F-layer ionization maximum with the results of simultaneous measurements of critical frequencies by ground ionospheric stations situated near the satellite's path. The data on critical frequencies of the F-layer during satellite's passing at altitudes near 300 km in the northern regions were determined by interpolation of data of ionospheric stations at Murmansk, Salekhard , Tiksi B. and Providence Bay, and for the satellite's position south of 40° by extrapolation of data of the Ashkhabad ionospheric station (southernmost in the USSR) and of world network stations.

Certain examples of such comparison are compiled in Table 2.

TABLE 2

DATE (MAY)	Time (Moscow)	Coordinates of the satellite			Critical frequency f_{cr} mc/s	Electron concentr.* 10^5 cm^{-3}	Positive ion conc. n_{i_o} $10^5 cm^{-3}$
		alt. km	lat.N	long.E			
15	1012	288	64.5	107.5	7.8	7.5	9.6
18	1039	356	65.1	114.6	8.3	8.5	7.5
21	9 00	311	27.5	43.9	12.2	18.0	14.0

*) according to data from ionospheric stations.

From the examples brought out one may see that the value of electron concentration n_{io}, determined according to data of ion traps aboard the satellite is close with a precision to 25% to that electron concentration determined according simultaneous observations of the ionosphere by ground stations of the same geographical region. Since local concentrations are determined with the aid of traps, and the mean concentrations in a large region of the ionosphere (defined by the first Fresnel zone for the wavelength corresponding to f_{cr}) — by the ionospheric stations data, the agreement of the results may be considered as satisfactory.

Hence, the following conclusions may be made :

1. Even if they are present, negative ions in the F-region of the ionosphere exist only in insignificant quantities (since the measured electron concentrations are about equal to those of positive ions).

2. The ionization of neutral particles of the air does not exert a notable effect on the results of measurements of n_i with the aid of ion traps because of satellite motion.

The absence of significant quantities of negative ions in the outer ionosphere provides the basis to estimate that the measured values of positive ion concentration may simultaneously be considered as values of electron concentration.

A substantial number of distributions of positive ion concentration along portions of satellite's orbit passing in the indicated region of the ionosphere was obtained as a result of processing of primary experimental data. Since the vertical velocity of the satellite is substantially less than the horizontal, no altitude dependence could be outlined in a clear form from the obtained distributions of positive ion concentration along portions of satellite's orbit. The results obtained near the perigee, where satellite's vertical velocity is particularly low, are evidence of the existence of significant horizontal gradient of charged particle concentration. However, despite the presence of horizontal variations of n_i, the plotting of the results of measurements in the system of coordinates (h, n_i), where h is the height above the ground, is of unquestionable interest. Although substantial horizontal variations are superimposed on the altitude course, such graphs still must correctly reflect the altitude course of n_i, provided they are somewhat smoothened, since at altitude variations by hundreds of kilometers, the concentration n_i varies by one order, while variations along the horizontal are significantly lesser. As to the small n_i variations with height, their separation from those along the horizontal cannot be made during measurements by means of traps.

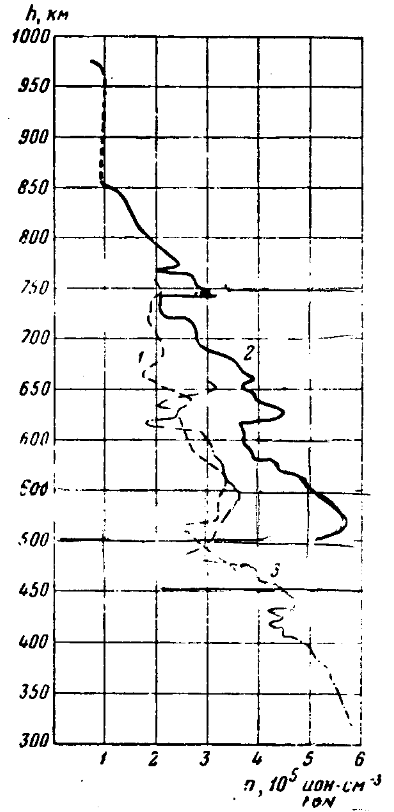


Fig. 4.

Distribution of concentration in height of positive ions:

1 - 5th revolution 15 May
2 - 56th - 19 -
3 - 68th - 20 -

Plotted are in Fig. 4 examples of variation of positive ion concentration n_i with height, related to the 5th convolution of the 3rd AES around the Earth on 15 May at 17 00 hours (graph 1), to a part of the 56th and 68th convolutions, respectively of 19 May at 11 00 hours and of 20 May at 09 00 hours (graphs 2 and 3). A series of other graphs of $n_i(h)$ related to various heights and different satellite convolutions arounf the Earth were published in [6], and part of the materials has now been made ready for publication.

To characterize the degree of ionosphere changeability above 500 km, we compiled in Table 3 the following values obtained according to data at times of different satellite convolutions for two altitude intervals (from h_o= 500 km to h_o+ h = 600 km and from h_o = 600 km to h_o + h = 700 km)

1. n_i (h_o) – the ion concentration at the altitude h_o.

2. The relative decrease of n_i at altitude increase to 100 km, i.e.

$$\frac{\Delta n_i}{n_i(h_0)} = \frac{n_i(h_0) - n_i(h_0 + \Delta h)}{n_i(h_0)}$$

3. The mean value of the gradient of ion concentration for altitude increase by 100 km, expressed in $cm^{-3}\,km^{-1}$, i.e.

TABLE 3 *)

Altitude interval km	Date 1958	Time Moscow	Number of convol.		$\frac{\lvert \Delta n_i \rvert}{n_i(h_0)}$	$\lvert \overline{\text{grad}}\, n_i \rvert$, 10^3 cm$^{-3}\cdot$km^{-1}
500 ÷ 600	20.V	08 30	68	5.9	0.15	0.88
	31.V	05 30	216	4	0.45	1.8
	3.VI	05 00	256	2	0.3	0.6
600 ÷ 700	15.V	17 00	5	2.5	0.27	0.68
	18.V	10 30	42	2.6	0.32	0.83
	19.V	11 00	56	4.2	0.33	1.39

*) The values in the last column of Table 3 differ somewhat from those brought out in the Cospar Symposium Reports (Amsterdam, 1961) where inaccuracies were admitted by author's fault.

3. DATA ON CHARGED PARTICLE CONCENTRATION IN THE PERIPHERAL REGION OF THE IONIZED GAS ENVELOPE OF THE EARTH ACCORDING TO THE RESUETS OF EXPERIMENTS WITH CHARGED PARTICLE TRAPS ON SOVIET COSMIC ROCKETS.

The collector current of every ion trap installed aboard the third AES was the sum of two components : I_i created by the atmospheric "thermal" ions, and I_o, determined by the effect of solar ultraviolet radiation and charged eneregtic particles upon the collector. The ratio $\frac{I_i}{I_o}$ must decrease as the ion concentration decreases with altitude increase, and the determination of n_i may become difficult, and even impossible for sufficiently small I_i.

That is why the necessity arises to change the trap's construction for the measurement of low ion concentrations (for example $n_i < 10^3\ cm^{-3}$): namely by introducing a third electrode — an additional grid, installed between the collector and the external grid. A rather great negative potential is fed on that grid relative to the collector, creating an electric field which overwhelms the photo electron emission and the secondary emission of electrons from the collector appearing under the effect of energetic charged particles.

Such type of traps were installed on Soviet cosmic rockets permitting to register weak currents, induced by fluxes of various charged particles at different portions of these rockets' trajectories, including the currents, induced by positive ions of the ionized gas envelope of the Earth.

We shall consider in the present report only the part of the results of the experiments with three-electrode traps, which were obtained in the immediate vicinity of the Earth ($h < 4 R_E$). The results obtained at great distances from the Earth will be discussed in a separate report.

Since statistically the most lucrative results of experiments with three-electrode traps in the near-terrestrial portion of the trajectory were obtained during the flight of the second cosmic rocket, launched toward the Moon on 12 September 1959, in the following we shall mostly describe data of that flight, although results obtained in the first and third Soviet cosmic rockets will also be utilized [8 — 10].

Four three-electrode traps were installed at summits of a tetrahedron inscribed in the sphere of the spherical container with scientific payload, having separated from the second cosmic rocket. Each trap consisted of an external semi-spherical grid of 30 mm radius made of nickel, and inside of which there was a flat nickel-made collector. Between the collector and the exterior grid there was a plane inner wolfram grid (Fig. 5). The potentials of traps' elctrodes relative to the frame of the container were as follows : for collectors

$$\varphi_K = (-60) \div (-40)\ \mathrm{V}$$

for the inner screen of all traps

$$\varphi_{g2} = -200\ \mathrm{V},$$

and the exterior screen of the four traps had the potentials :

$$\varphi_{g1} = -10,\ -5,\ 0 \text{ and } +15\ \mathrm{V}$$

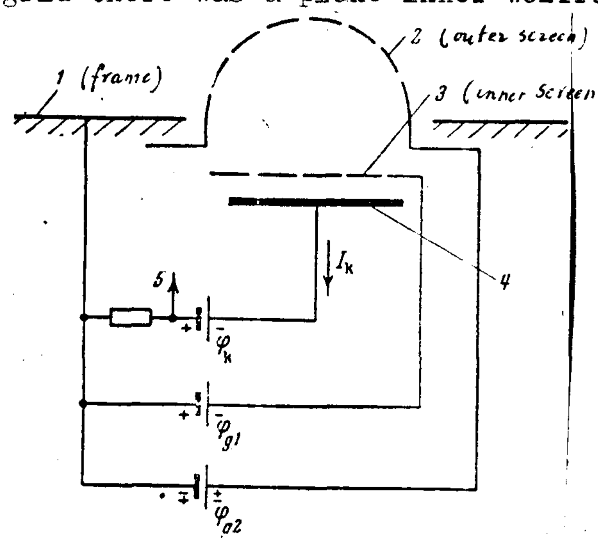


Fig. 5. Scheme of a 3-electrode trap.

The magnitude of the electric currents induced by charged particles hitting the traps, were transmitted to ground by way of radiotelemetric apparatus, which allowed during the utilization of collector current amplifiers to register positive collector currents I_K from 10^{-10} to $50 \cdot 10^{-10}$ a and the negative collector currents to $15 \cdot 10^{-10}$ a. The instantaneous values of each collector current were registered twice a minute.

In reviewing the primary material it was noted, that at distances from the Earth's surface of less than 20 000 km, significant positive currents were observed in all traps, except for those with the potential $\varphi_{g2} = +15$ V decelaring the positive ions. These currents dropped rather sharply in the region $h \approx (18 \div 20)$ th. km. At the same time, inside that region, the magnitude of each trap's currents oscillated rather strongly.

Fig. 6 shows the values of the collector currents I_K in the trap with $\varphi_{g2} = 10$ V, and Fig. 7 describes the values of the currents I_K in the traps with $\varphi_{g2} = 0$ V, and $\varphi_{g2} = +15$ V (the currents of that last trap are marked by crosses). The observed oscillations of currents are linked with the fact, that being displaced along the trajectory, the container with the scientific payload effected simultaneously complex fast rotational motions, inducing continuous variations in the orientation of each trap relative to the velocity vector and the direction to the Sun.

The greatest values of currents apparently correspond to container orientation close to optimum orientation for the given trap (for which the normal to trap's collector obviosuly coincides with the container's velocity vector, for the flux of ions then reaching into the trap is greatest). That is why the variations of the values I_k along the trajectory, mostly dependent upon the surrounding medium, may be described with the aid of curves enveloping the greatest values I_k; at the same time the effect of container's rotation on the results of the experiment may to a certain extent be neglected.

Figure 8 indicates the boundaries of various traps' collector currents in the considered portion. The absence of similitude in the course of the curves of Fig. 8 is apparently explained by the peculiarities of variations in the orientation of various traps relative the container's velocity vector, and this is linked with their various disposition on the surface of the container, rotating in a complex fashion.

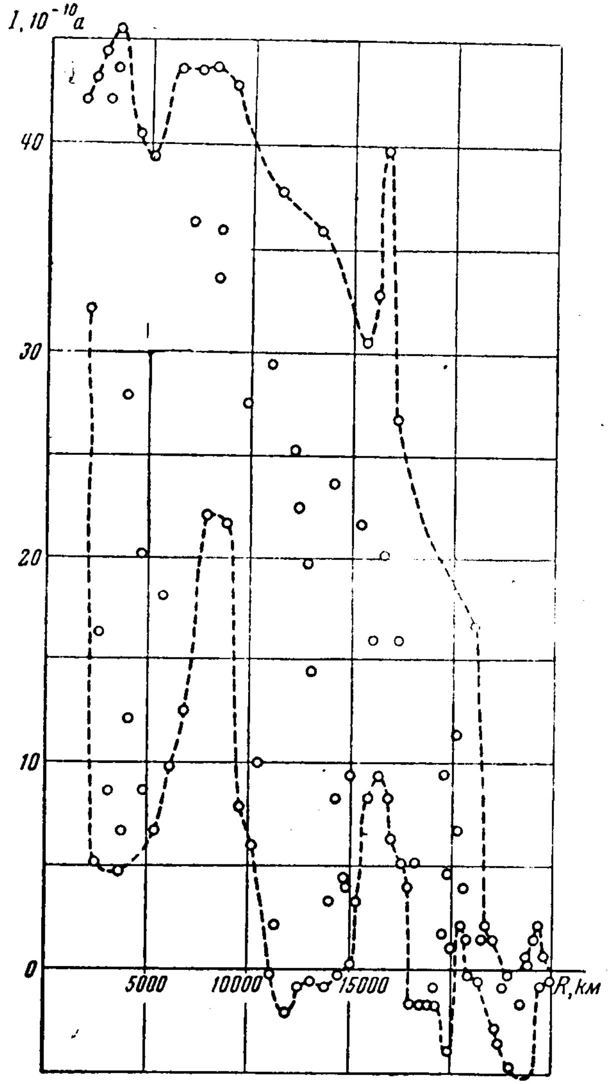


Fig. 6. Values of collector currents registered in the trap with φ_{g2}= -10 V over the portion R < 25 000 km

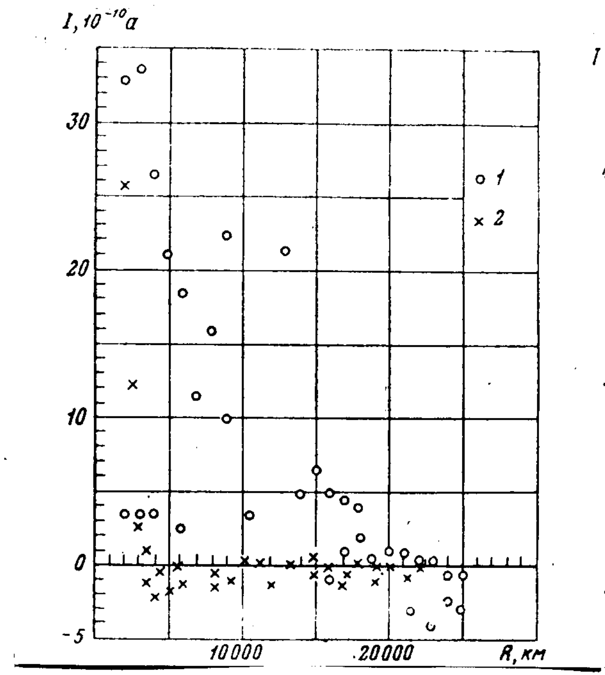


Fig. 7. Values of collector currents registered in the trap with φ_{g2}= 0 (1), and in the trap with φ_{g2}= + 15 V (2).

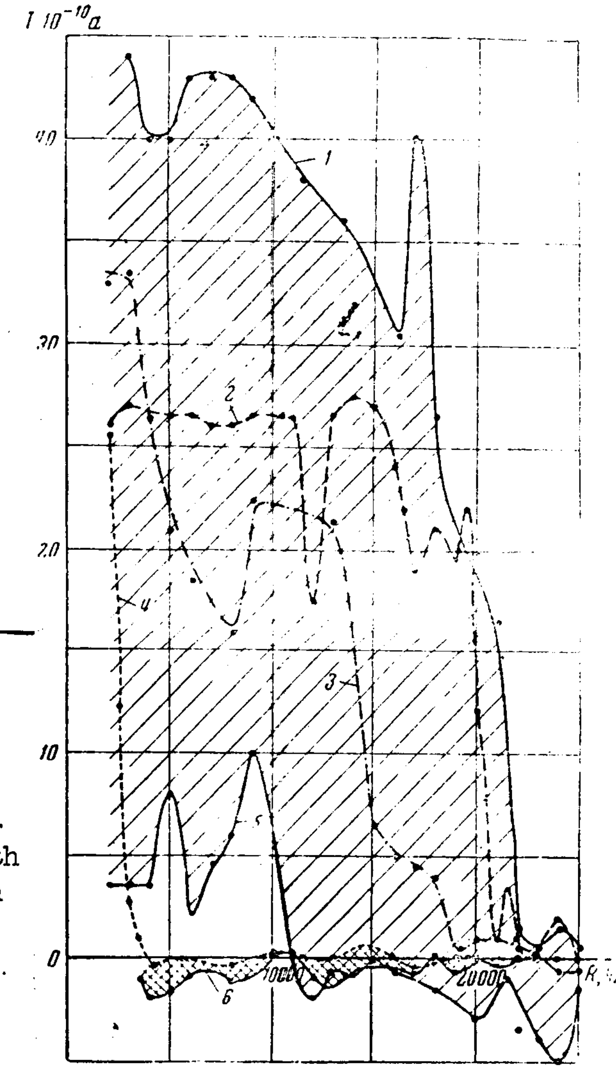


Fig. 8. Boundary of collector current values over the portion R < 25,000 km

Upper blundaries: 1- at φ_{g2} = -10 V; 2 - φ_{g2} = - 5 V; 3 - at φ_{g2} = 0; 4 - at φ_{g2} = +15 V. Lower boun-daries 5 - general for traps with φ_{g2}= - 10, -5 and 0 V. 6 - at φ_{g2}= +15 V.

Plotted is in Fig. 9 the upper boundary of the collector currents in the traps with $\varphi_{g2} = -10$ V and 0 V, measured during the flight of the container of the first Soviet cosmic rocket on 2 January 1959.

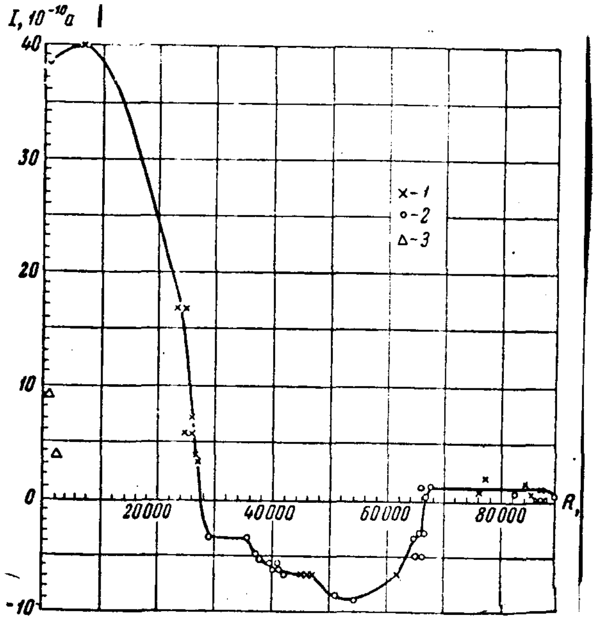


Fig. 9 (see text)

1 — trap with $\varphi_{g2} = -10$ V
2 — " " " = 0;
3 — " " " = + 15 V.

Fig. 10 shows the collector currents measured in the traps with $\varphi_{g2} = -10$ V and +25 V during the flight of the 3rd cosmic rocket in 4 October 1959. In this case measurements were made only to a distance $h \approx 7000$ km where the first session of radio-communication with the interplanetary session terminated.

It is interesting to note that systematic positive currents were observed in the three indicated experiments to about 2000 km, and whose nature is obscure. These refer to observations with traps with $\varphi_{g2} = +15$ V.

At altitudes above 2000 km only negative currents were observed in all cases in traps, on whose outer screens there was a decelerating positive potential. These negative currents were induced by photoemission of electrons from the inner screen.

The examination of the experimental data brought out shows that at distances from the surface of the Earth of about four Earth radii, an ionized gas is being detected with a temperature of the order of magnitude not exceeding 10^4 °K. This follows from a quite clearly visible in the drawings substantial effect of comparatively small differences in the potentials of traps' outer screens (5 V) upon the magnitude of collector currents, inasmuch as these drawings refer to the flight of the second cosmic rocket.

To obtain quantitative estimates of positive ion concentration at the portions of second cosmic rocket's trajectory where $h < 4R_E$, we utilized the values of traps' currents, when the trap's exterior screen was connected with the container's frame ($\varphi_{g2} = 0$), under the following admissions :

1. The maximum registered current values correspond to the optimum orientation of the trap (in the sense emphasized above). It is clear that this admission may be cause of error in the determination of the current corresponding to trap's optimum orientation. In each separate case it is possible though that the current registered is less than that corresponding to the optimum position of the trap by, say, 50%.

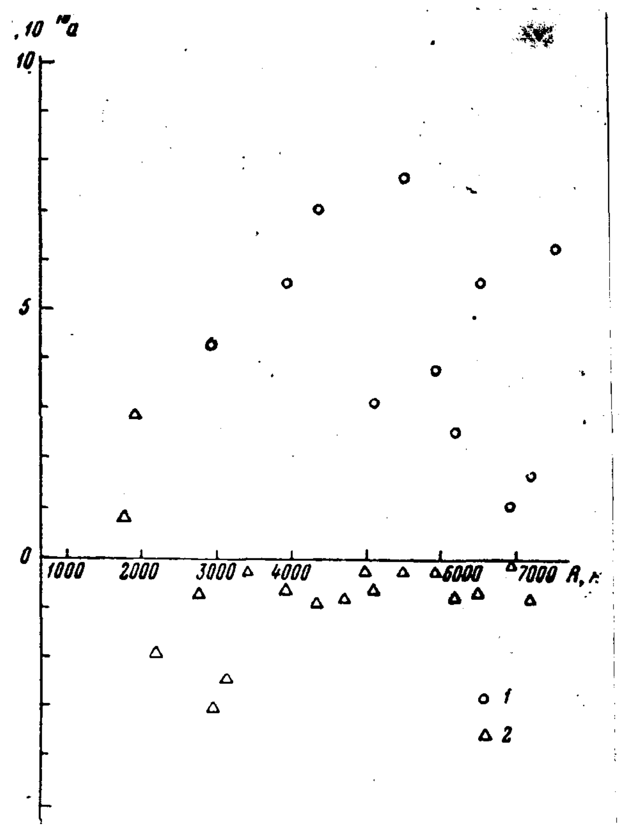


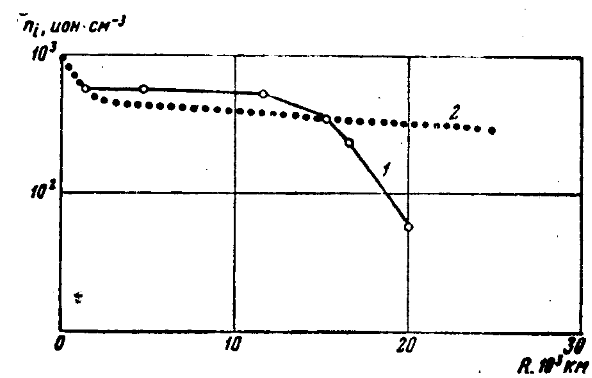
Fig.10. Collector currents measured in traps with φ_{g2} = - 10 V (1) and φ_{g2} = + 25 V (2), installed aboard the 3rd cosmic rocket (4 October 1959)

2. For the optimum orientation of the trap the current of ions getting into it, may be estimated as a current on the portion of an infinite plane probe, moving with the container velocity V_o in a plasma with a Maxwellian distribution of ions, with the ion concentration n_i and temperature T_i. This admission is based upon the fact that the radius of the trap is small in comparison with that of the container, and that the surface of the considered trap (its outer screen) is equipotential with the closest vicinity of the container's surface. It must be added that the density of the ion current on the

portion of container surface, normal to the vector of its velocity, which does not exceed in absolute magnitude the thermal velocity of ions, depends substantially less on the sphere's potential, than the ion current density on the other portions of the surface.

The correlations, with the help of which the ion concentration is determined by the measured currents, are examined in [6], and we have no possibility to dwell upon them in the present work. Let us only note, that near the Earth the container's velocity knowingly exceeds the thermal velocity of ions, and that is why the current, corresponding to trap's optimum orientation, must be little dependent on thermal velocities, and consequently, on ions' mass and temperature too.

If we estimate that hydrogen ions with temperature $T = 2000^{\circ}K$ reach the trap, we plot according to data obtained on 12 October 1959 the graph of ion concentration variation with height, as shown in Fig. 11. The dependence of these results on the assumed temperature is quite small. At $T = 50\,000^{\circ}K$, the curve descends only insignificantly. The assumption that atomic oxygeb ions predominate at the considered heigths, and also below 1000 km, also changes little thr results (the region of small gradients may be explained if temperature is increased to $15\,000^{\circ}K$).



1 - experiment; 2 - computed curve

Fig. 11.

If we plot the theoretical distribution of hydrogen concentration by the barometric formula, taking into account the curvature of the layers of equal density, marked by black circles in Fig. 11, the comparison of these two curves shows, that the region corresponding to $h < 15\,000$ km, is easily explained, while the sharp variation of gradients of n_i by altitude in the region $h > 15\,000$ km requires a special analysis.

It must be stressed, that the existence of that region of increased negative gradients is not subject to doubts, for the decrease of collector currents is observed in three traps with $\varphi_{g2} \leqslant 0$, oriented in different fashion, and that is why it cannot be explained by an unfavorable orientation of the container.

Comparison of curves plotted in Fig. 11, provides the basis for considering, that beginning with $h \sim 1700$ km (minimum height at which current registration by traps has begun) to $h \sim (20 \div 22)$ thousand km. the Earth is surrounded bu ionized hydrogen and that, consequently, at heights from $h \approx 1000$ km and $h \approx 1700$ km the ionosphere changes from "oxygenized" to "hydrogenized".

The experiments just decribed have shown that the Earth is surrounded by an ionized gas shell of thickness to $h \approx 4R_E$ with ion concentration of the order of 10^3 cm^{-3}, substantially exceeding the concentration in the interplanetary medium. The question of estimate of ion concentration in the interplanetary medium is examined at further length in [11].

4. CONCLUSION

The results of the experiments, expounded in the preceding paragraphs, which have been carried out in the outer ionosphere, allow the construction of an approximate vertical distribution of free electron concentration or (above the F-region maximum) of the positive ion concentration in the Earth's gas envelope which is numerically equal to the former, entirely based upon experimental data. Since such distribttion (Fig.12) is based on meansurements, conducted from February 1958 through September 1959, it naturally reflects the state of the ionosphere during a period close to solar activity maximum.

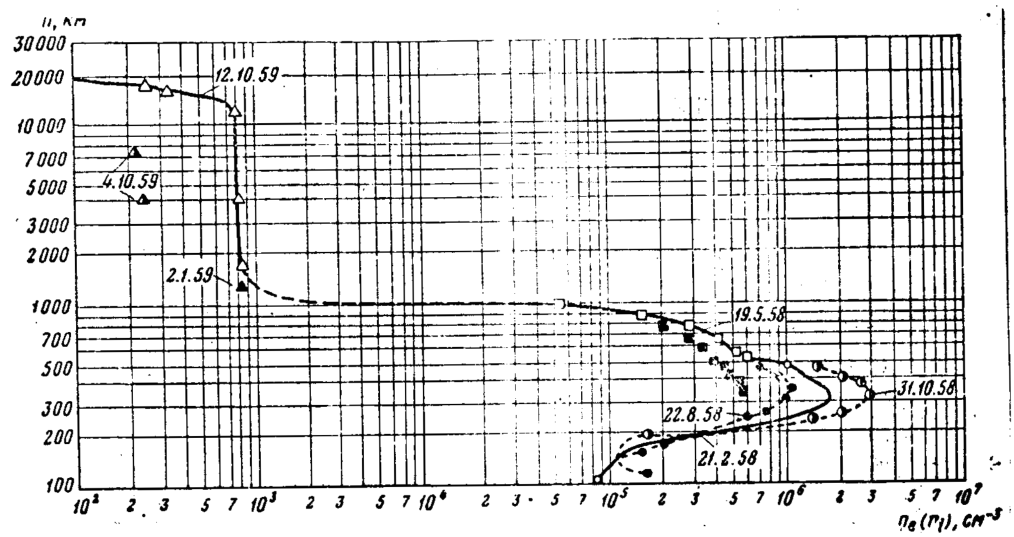


Fig.12. Approximate distribution in height of charged particle concentration for the period near the solar activity maximum.

In constructing the lower part of the graph we utilized the data of one of the vertical launchings of geophysical rockets (21 February 1958). The middle part is constructed according to data on measurements over a portion of the orbit of the 3rd AES at time of its 56th orbit around the Earth. The part of the graph with $h = 1400$ km to $h \approx 20\,000$ km is constructed according to data provided by measurements aboard the 2nd cosmic rocket. Certain points are plotted near the curve, which were obtained at measurements at the giben heights at a different time (either on other geophysical rockets or during other orbits of the 3rd AES, on the 3rd and first cosmic rockets). These ppints characterize to a certain extent the ionosphere variability.

Concerning the points relative to the thrid cosmic rocket, the following should be noted: Two traps, with respective potentials $\varphi_{g2} = +25$ V and $\varphi_{g2} = -10$ V in their outer screens were switched on the near-the ground portion of the trajectory. The currents registered in the trap with $\varphi_{g2} = -10$ V resulted about four times weaker than in the traps of the containers of the 1st and 2nd cosmic rockets with the same value φ_{g2}. This may be explained by concentration decrease of ions at heights of the order of 1000 km, but at the same time we cannot consider as excluded the fact that the decreased current values are explained by the unfavorable orientation of the trap (this assertion cannot be verified, since there were no other traps switched on over that portion of the trajectory with $\varphi_{g2} \leq 0$, and differently oriented at the surface of the container).

The measurements on the basis of which the upper part of the graph was constructed, were the first direct experiments for the study of the peripheral part of Earth's gas envelope. They are but the beginning of the investigation of that region.

Numerous measurements of ion concentration in the peripheral part of the Earth's gas envelope must be conducted in the future, and the stability of its height together with its dependence on the geographical latitude must be verified. It should be hoped that such measurements will allow a multilateral verification of the stability of that region's characteristics.

Theories of ionosphere formation were established at times, when the only source of information on the structure of the Earth's gas envelope resided in radiosounding with the help of ground ionospheric stations, which explained satisfactorily the experimental data then available. The experiments with the aid of AES and cosmic rockets compel us to seek a way for the creation of a new theory, capable of satisfactorily explaining the facts that became known lately. Related -- to the number of such facts in particular is the significant increase of negative concentration gradients detected in the 15 000 — 20 000 km range, near the boundary of the Earth's gas envelope.

Aside from the author, a series of persons cooperated in various ways in the projects: V. A. Rudakov and A. V. Kaporskiy participated in working out the apparatus, in carrying out experiments with the dispersion intereferometer and in the processing of results. V. V. Bezrukikh and V. D. Ozerov participated in working out the devices and conducting experiments with spherical ionic traps on the 3rd satellite, together with the processing of such results. They were joined by R. E. Rybchinskiy in working out of methods of experiments with three-electrode traps and relevant devices. Besides, in the interpretation relative to the experimental results of this report obtained with the aid of three-electrode traps, a group of coworkers, consisting of I. S. Shklovskiy, V. G. Kurt and V. I. Moroz, all of the Astronomical Institute in the name of Shternberg, have also participated.

***** THE END *****

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.. References follow..

R E F E R E N C E S

1. K. I. GRINGAUZ, V. A. RUDAKOV, A. V. KAPORSKIY., ISZ (AES), v. 6, p.33, 1961.
2. K. I. GRINGAUZ. Dokl. A. N.SSSR, 128, 1234, 1958 ; ISZ, v. 1, 1958
3. K. I. GRINGAUZ, V. A. RUDAKOV. Sb."ISZ", v. 6, p.48, 1961
4. K. I. GRINGAUZ, M. Kh. ZELIKMAN. UFN, 63, 239, 1957
5. V. I. KRASOVSKIY., Proceedings of the IRE, 47, 289, 1959.
6. K. I. GRINGAUZ, V. V. BEZRUKIKH, V. D. OZEROV, Sb.ISZ, v.6, 1961.
7. V. G. ISTOMIN., Sb."ISZ", v. 4, p.171, 1960.
8. K. I. GRINGAUZ, V. V. BEZRUKIKH and al. Dokl. A. N.SSSR, 131, 1301, 1960; Sb. "ISZ", v.6, p.101, 1961.
9. K. I. GRINGAUZ, V. G. KURT, and al. Dokl.A. N.SSSR, 132, 1062, 1960. ISZ, v. 6, p.108, 1961.
10. K. I. GRINGAUZ, V. G. KURT, and al. Astron.Zh., 37, 716, 1960.
11. K. I. GRINGAUZ. Sb. "ISZ", v.12(current issue), p.119, 1962.

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